reefs were turning out extraordinarily rich, far surpassing anything hitherto known. The Surveyor-General stated that the reefs were in granite and did not continue into the adjacent schistose rocks, and were horizontal. The discovery was made by eight miners, who in eighteen months had realized between forty and fifty thousand pounds each.

Mr. CRAWFURD asked if indications of tin had been found in Western Australia.

Mr. SELWYN replied, he had not seen any. Before he left, the Western Australian Government forwarded him some specimens of granite with mineral in it, which he found to be sulphide of molybdenum.

MAJOR SANFORD took exception to the conclusions of Mr. Hargreaves, and was about to enter into the question at some length, when the President begged him to postpone the discussion to a future occasion, in consideration of the importance attached to the next Paper which had to be read, "On the Glaciers of the Mustakh Range," and stated that an early opportunity would be afforded for considering the points mooted as to the capabilities of West Australia.

The second Paper read was—

2. *The Glaciers of the Mustakh Range* (*Trans-Indus*). By Captain H. H. GODWIN-AUSTEN, Assistant on the Great Trigonometrical Survey of India.

STARTING from Iskardo 5th August, 1860, the survey of this region may be considered as divided into two grand divisions, separated by a line drawn through Iskardo, Shigar, and a point on the great range of the Kuen-Lun, about 40 miles west of the Mustakh Pass, leading into Little Bucharia. This Mustakh Pass is a newly-discovered pass, described as being capable of being so far improved as to be practicable for ponies, though the height is 18,400 feet. It is separated to the eastward from the renowned Kara-Korum Pass by the magnificent range running eastward from the Kara-Korum Peak, as yet unnamed, the second highest peak in the Himalayahs or the world, which rises about north-west to an elevation of 28,265 feet. Its approximate position is 35° 53′ N., 76° 35′ E.,* that of Mustakh being 35° 49′ N., 76° 14′ E.

The first portion of the survey lay up the Hushi Valley, a tributary of the Nubra, which name the author applies to the whole length of the North fork of the Indus (in lieu of its customary designation of Shah-Yok), instead of confining it as hitherto to the tributary branch of that name which falls in a little above the junction of the Hushi Valley. At the head of the valley he encountered three glaciers, the easternmost of which he traced into the recesses of the immense mass of the Masherbrum (35° 38′ N., 76° 20′ E.), 25,600 feet high. After surveying these in regular order, he

* The positions assigned in this abstract are only approximative as derived from the Map.—ED.

returned to the junction of the Hushi with the Nubra, and thence westward 24 miles down the river to Kapaloo, 35° 10′ N., 76° 24′ E., which is itself about the same distance above Iskardo, whither he returned after twenty three days' arduous labour, and which was the head-quarters of the survey.

Captain Godwin-Austen next proceeded to determine a position for the triangulations to the south of Iskardo, the panorama from which, embracing nearly the whole extent of the peaks from Masherbrum westward, was magnificent.

That season being finished, it was necessary to postpone any further survey till 7th July, 1861, when a survey was made to the south-west of Iskardo as far as the Pass of Borijee. Thence he returned to head-quarters, and at once started for the village of Kuardo, having now completed the examination of the very remarkable basin of Iskardo, which bears evident traces of having been once an immense lake. Here the weather proved unpropitious, as it was throughout the season, but with occasional bursts of clear weather, when the views from the peak over Kuardo from south round to north-east—from the mountains bounding the table-land of Deosia over Kashmere round to the great Kara-Korum Peak—were grand beyond description. Shigar was finally reached 18th July.

On the 28th he proceeded to explore the Valley of the Bialdoh, which, rising in the distant glaciers of Punmah and the ridge bounding the great Baltoro glacier on the west, receives large numbers of glacial tributaries (the ice-cold water of which had frequently to be forded), and flows westward to a point where it receives the Basha, a similar glacier stream from the north, when the united streams flow in a S.S.E. direction, and take the name of the Shigar. Not long after setting foot in the valley, the party, while at camp, were nearly being swept away by the bursting of a glacier-lake, which rolled along huge blocks of rock and torrents of black mud,—a phenomenon which is called by the natives "Shwā," and is of by no means infrequent occurrence, corresponding, in fact, to what is known to Alpine travellers as a *débacle*.

After exploring the Pass beneath the peak of Mango Guror, Captain Godwin-Austen held eastward to the little hamlet of Askoleh, where the Bjaldoh is crossed by a rope-bridge of 270 feet span, very safe, but very lax, and proportionately difficult. Thence over the glacier of Biafo, whence he held northward to the station known as Isok, 35° 47′ N., 76° 2′ E., the very centre of a ganglion of glaciers, streaming down from the west flank of the Masherbrum. In the very heart of this bleak region they encountered four Balti emigrants, returning

from Yarkand to pay a visit to their native vales, who gave a grim account of their sufferings crossing the Kuen-Lun.

Arrived at a point where four glaciers meet, he prosecuted his search up that to the north-west, known as Nobundi-Sobundi; returning from which, after a constant succession of ascents, including frequent bivouacs at great elevations, or on the ice, he reached the Mustakh Pass, which he ascended to within 500 feet of the top, when the weather compelled him to return. From this point he retraced his steps by the opposite side of the glaciers previously explored, to the junction of the Bialdoh with the Biafo, which is the outlet for the melted snow and ice contributed by the great glacier of Biafo, extending north-west 35 miles at a stretch to the ridge bounding the valley of Nagayr. There is also another glacier-feeder from the N.N.E., which was first examined; over which, immediately below the Mashferbrum—which though unseen, owing to clouds, towered immediately overhead—lay the old Pass to Yarkand, discontinued on account of the great increase of late years of snow and ice, and the abandonment of which led to the Mustakh Pass being made use of. Examples of such changes within the memory of living men are quite common, and the Paper instanced two or three such.

Still penetrating into the heart of the glacier, the author began to look out for the great Kara-Korum Peak already mentioned, and not seeing it, began to fear that it lay beyond the watershed dividing the Upper Indus from Thibet. But a sudden turn, at one part of his route, revealed the giant peak towering in all its glory, an almost perfect cone, rising 14,000 feet above the point of view, and almost exactly on the line of demarcation. The weather now changed once more, and became so bad that it was impossible to push up the Biafo glacier as intended, and so pass over into Nagayr, whence he proposed to return by the pass of Nushik, 36° 13′ N., 75° 13′ E. Accordingly the party descended the Bialdoh, passing the Holy Rock of Shandseo Pîr, over the village of Dasso, and so reached Tandoro on the Shigar.

From this point preparations were made for a short exploration of the other chief stream of these regions, the Basha. Leaving Tandoro 29th August, Chutrum was reached on the second day, whence the road (the travelling on which is excellent) lies up a singularly picturesque valley, that of the Basha, running first north, then west, as far as Arindoh (35° 52′ N., 75° 23′ E.). At Doko, about halfway up the valley, a magnificent view was obtained over the great glacier feeding the river, and to the Haramosh Mountains, (35° 50′ N., 74° 57′ E.) to the west. After a ten days' excursion on the glacier, on which their night's bivouac was made, the exploring

party passed up the Kerò Loombah (Loombah means ravine in Thibetan; La, a pass; and Ganse, a glacier), where were numerous traces of bears, though none were seen. Beyond this the Kerò glacier, which had now been reached, split into two; following up the main branch of which, two "kennels" for the use of travellers were passed, and the pass of Nushik came into view, an ice-bed gently sloping upwards between perpendicular cliffs to an elevation of 19,000 feet. This glacier extends unbroken down the other side as far as Hisper in Nagayr, 36° 9′ N., 75° 5′ E. This finished the north watershed of the Basha branch of the Shigar. Returning, ineffectual attempts were made to push to the westward, and ultimately the party returned to Arindoh, having completed an accurate survey of the whole Upper Shigar, the most striking features of which are the great glacier of Biafo, and the ever present proof that the glaciers are everywhere and rapidly encroaching on the soil fitted for agriculture; so that, in some places, land which formerly yielded two crops can now only bear one, owing to the altered temperature.

From Arindoh, the expedition now made for the Tormik, over the Ganto La (Pass), and reached Hŭrimŭl, whence the upper portion of the valley was surveyed, in which a hot spring (104° F.) was found. Captain Godwin-Austen now descended to the confluence of the Tormik with the Indus, which was crossed by the rope-bridge of Mendi, 35° 35′ N., 75° 15′ E., whence he proceeded up the river to Iskardo, passing on the way a terrific pass cut along the face of a precipice overhanging the river, hundreds of feet below. At Shigar-Thang, 35° 18′ N., 75° 23′ E., the surveyor turned south-west to the Alumpi Pass, on which numerous skeletons were found, attesting the fate of a large party lost in the snow some years before. From this point, the season being broken and the survey ended, they pushed on into Cashmere.

The PRESIDENT, after expressing the thanks of the Society to Captain Godwin-Austen, said he was delighted that this communication should have come from the son of a man who had done more than any Englishman he knew to connect physical geography with ancient geological phenomena—Mr. Godwin-Austen; and as that gentleman was present, he congratulated him upon having a son to produce such a Paper. They were fortunate in having a gentleman present who had carefully explored these high regions,—that distinguished geologist and naturalist, Dr. Falconer, who was so long at the head of the Botanical Gardens of Calcutta. They would be delighted to hear from him a confirmation of the Paper. The great value of the Paper was that Captain Godwin-Austen, as one of the Trignometrical Survey of India, had actually fixed the delimitation of these physical features in geography. The Paper might have been read before the Geological Society; and he would only call attention to one fact contained in it, that all the glaciers which the Alpine Club were in the habit of ascending were mere pigmies in comparison with these glaciers of the Himalayahs. The very

tributaries to these glaciers were eight or ten miles long, while the great glacier of Mustakh, to which their attention had been called, was thirty-six miles long in the part of it which was surveyed.

DR. FALCONER, after describing the progress of the Trigonometrical Survey in India, next drew attention to the glacier system of the Himalayahs. All the best observers—Dr. Thomson, Jacquemont, and others—had been of opinion that there was but one great system of mountains. There was no such thing as any break of mountain-range, or any distinct mountain-chains. There were great rivers which cut them across, rivers like the Indus, the Sutlej, and some feeders of the Ganges; but, regarded in one grand aspect, they constituted a series or mass of mountains with ravines and valleys intervening. Viewed, then, in this light, there were two great ranges which culminated to especially great altitudes, and which bounded the Indus river to the south and the north; and this being one of the points where the Himalayan chain attained its greatest elevation, there the glacial phenomena were developed in most grandeur and upon the loftiest scale. The paper referred to that part of the range which bounded the valley of the Indus upon the north, the Kara-Korum or Mooz-tagh or the "Icy Range of mountains," and the other great series of them were the mountains which bounded the Indus upon the south. Although the glaciers upon the Shigar valley and in the valley of Bialdoh, which he himself had visited in 1838, were of such surpassing grandeur and importance, as had been mentioned by Sir Roderick Murchison, it was but fair to other observers to say that upon the northern side there were glaciers which, so far as description went, were equally grand, if not grander. Those to which he should especially refer were the glaciers at the head of the Zanscar river, the sublime features of which had been so well described by Dr. Thomson. Mr. J. Arrowsmith, from his labours on the maps of Hugel, Thomson, and other explorers, was well acquainted with the mountain-ridge to which he referred and the glaciers which arose from it. There was the river called the Chenab, and a mountain-range which stretched across between the Indus and the Chenab. The pass of the dividing ridge at this point was 18,000 feet above the level of the sea; and upon either side, but more especially upon the north, at the heads of the Zanscar river, were some of the grandest glacier phenomena which were to be seen in any part of the world. There were glaciers extending from a very great distance, which attained enormous width—confluent into a sea of ice—and which, until the description that had been given by Captain Godwin-Austen, had been unrivalled by any glacial phenomena with which they were acquainted, except the glacial formations in the Arctic regions, such as the Humboldt glacier in Smith's Sound, described by Dr. Kane.

With regard to the glaciers upon the north, the Indus ran through a long depressed valley westward, receiving from the north three great branches; the first branch, called Shayúk, from the Kara-Korum, next the Nubra river, and also the Shigar, which was the especial object of Captain Godwin-Austen's communication. Now, the Shigar valley was the third of importance of all the affluents of the Indus, and was bounded by mountains of a great elevation. Some of them which had been measured by Major Montgomery attained a very great elevation; one a height of 28,000 feet above the level of the sea. This naturally entailed a prodigious amount of condensation of the moisture of the atmosphere, and led to a very heavy fall of snow, the result of which was seen in these glacial phenomena. Twenty-seven years ago he had been up to Arindoh, the extreme termination of the western or Basha branch, and from that point by a détour he got across upon the other valley by the Scora-là Pass to the glacier of the Bialdoh river, where he saw all the phenomena which had been described by Captain Godwin-Austen.

Having premised this much with regard to special details, there were one

or two points which he was desirous to bring before them. One was, What were the peculiar characteristics of the Himalayahs, as well as of all tropical mountains, as compared with our European mountain-chains? There was one characteristic of the Himalayan chain so remarkable that he should take the liberty of explaining it at some length. He presumed that most of his audience had visited either the northern or southern side of the Alps; and those who had been in the plains of Italy, along the valley of the Po, were well acquainted with the numerous lakes which jutted out from the Alps into the plain of Italy. Commencing on the west they had got the Lago d' Orta, the Lago Maggiore, the Lago Lugano, the Lago di Como, the Lago d' Iseo, and the Lago di Garda; in fact, wherever a great valley projected itself from the chain of the Alps at right angles to the strike of the chain, there they had with a single exception uniformly a great lake. Regarding these lakes in a general way, without reference to detailed phenomena, they found one thing which was constant about them—"they were invariably narrow, and some forty or fifty miles long, as notably in the case of Maggiore, Como, and Garda." The next remarkable thing about them was that they invariably radiated out at right angles to the strike of the great chain of the Alps. The Alps made a curve from the Pennine round to the Rhœtian Alps. They would also observe that those lakes were severally fed by a considerable river which proceeded from a high ridge of the chain, and which was thrown forward into the plains of the valley of the Po.

If they would consider the Himalayahs, or any tropical range of mountains whatever, in a similar way, they would find that those lake-phenomena were invariably wanting. Great rivers like the Indus, the Chenab, the Sutlej, and the Ganges, which passed through the Himalayan Mountains and debouched into the plains of India, had got valleys of infinitely greater importance than the valleys either to the north or south of the Alps; but they were never connected with a lake.

The question then arose, What was the physical reason of this great difference between the tropical mountains and those of temperate Europe? Nearly thirty years ago, he was for ten or twelve years rambling about the Himalayahs along a stretch of 800 miles, and he used to open a map before him, and try to make out the comparative features of European and Eastern mountains. He looked to the numerous lakes to the north and south of the Alps; and he would put the map of India alongside, where the same kind of rivers were debouching into the plains, but where there was an utter absence of lakes in connexion with them; and he used to puzzle himself in trying to discover a physical explanation of this difference. He was perfectly satisfied there must be some secondary conditions which were not common to the two, and he determined that, on his return to Europe, he should make them the subject of special research; for at that time the glacial investigations of Charpentier and Agazir in the Alps were unknown to a solitary wanderer in the Himalayahs. That intention he had carried out, by repeated visits to the Italian valleys of the Alps. There was the same kind of elevation above the level of the sea, the same kind of valleys, the same kind of fissures intersecting the great ridges,—What then was the explanation? This he would endeavour to indicate. About two years ago, as his friend Sir Roderick Murchison was aware, a Paper was brought before the Geological Society of London, by Professor Ramsay, which excited a great deal of attention, and gave rise to a very animated discussion. The theory of the Paper was that, as a rule, lakes in all the temperate and cold regions of the world were the product of glacial excavation; that is to say, that wherever a glacier descended from a high ridge of mountains into a plain, it ploughed its way down into the solid rocks and carved out a great lake. This was the theory or rather hypothesis which Professor Ramsay put forward, to explain the lakes which were so abundant in the

valleys of the Alps. A similar speculation, but greatly more restricted, had been advanced by Martillet a short time before. He limited the action of the glacier to scouring out the silt of the filled up lake-basins, the origin of which he attributed to antecedent fissures the result of upheavement. An application of this theory was made to the different physical phenomena which were connected with the case; and it occurred to himself and many others (and he believed Sir Roderick had an opinion in common with himself), that it was not adequate to explain the phenomena; and on the occasion when it was produced, he met it with the most lively opposition in connection with his own experience in the Himalayan Mountains. The opposition which he gave to it was upon these grounds. Many of them would remember that the lakes Maggiore and Como were upon the edge of the plains of Italy; that the glaciers —say that of the Ticino, which came down into the Lago Maggiore—descended along a steep incline, and were at last delivered into that lake, which was about 50 miles long, and only 8 or 9 miles wide at its widest point. Its prolongation nearest to the Mediterranean attained a depth of about 2600 feet below the level of the sea. Where the river escaped out of the lake it was not more than about 600 feet above the level of the sea. It was a remarkable point in the case that this glacier, by the hypothesis, should have ploughed its way down, and actually dived into the bowels of the earth 2000 feet below the level of the Mediterranean, and then should have again risen up along an incline at a rate of about 180 feet per mile.

Without going into all the objections, he might state he believed the principal one was, that the mechanical difficulties in the case were entirely left out of sight by the supporters of that theory; and on that occasion, after very long study of the subject, he endeavoured to bring forward what occurred to him as the true explanation of the difference between the Himalayan Mountains and the Alps. The difference he believed to consist in this: that after the last upheaval of the Alps, great fissures, or basins of lakes, were left there, with rivers running into them, in the manner in which the Rhone runs into the lake of Geneva, bringing down vast quantities of silt, which, if you give a sufficient number of ages, would have completely filled them up. But before this was accomplished, what is called the glacial period set in; that is to say, there was an enormous projection of ice and snow, below the limit that they now saw it in the Alps, out into the plains, both to the north and south of that chain; and, as the snow and ice came down, they filled up those lakes and formed a bridge, upon which the moraine material was carried over, there being a certain measure of incline from the summit of the Alps down to the plains of Italy. When once the basins were filled with ice to the depth of 2500 feet, they made, as it were, a slide or incline, upon which all the solid material could be transported; and that being carried forward by the *vis motrix* of the mass, formed the large moraine which we saw at Lake Maggiore, that of the Brianza, and also the moraine which bounded Lake Garda, where the battle of Solferino was fought. This was the secondary condition that occurred in Europe. Precisely the same primary conditions occurred in the great valleys of the Himalayahs, but without the same glacial phenomena. These mountains were thrown up above the level of the sea, and vast perpendicular fissures left, forming what constituted at that time the basins of lakes. But in those tropical regions the ice never descended from the highest summits down into the plains of India; and instead of being filled up by snow, which afterwards melted into water, these lake-basins were gradually silted up by enormous boulders and alluvium of every kind, which were transported down from the Himalayan Mountains in prodigious quantities by the torrential action of the periodical rains. The difference in the two cases was, that whereas the ice filled up the lake-basins in the Alps, constituting, as it were, the conservative means by which those lakes were saved from being silted up by

alluvial and other matters; in the Himalayan Mountains this conservative action did not take place, and the lake-basins remaining open got filled up in the manner which they had been told. If they would look at the map of the Himalayahs, one of the most remarkable things they would observe on the southern side of the chain, was, that there were no great lakes whatever—not one that would compare with Lake Lugano, or with any of the second or third rate lakes in the Alps. But if they crossed to the northern side of the chain, where the temperature was much colder during the winter, there they would find great lakes. The cold produced the same conservative action on the northern side of the Himalayahs, in preventing the lakes being filled up, which it did in the Alps by restricting the silting action.

This was the main fact to call to the attention of the Society, with reference to the great difference between the Himalayan and other tropical ranges of mountains and those in Europe. The next point was one of some interest and importance. There was a material well known in commerce and arts, called borax, now largely employed in ceramic products. It used only to be got from India as an export from Thibet, and it was invariably found in connection with hot springs. Within the last twenty years, a remarkable change had taken place. The late Count Lardarelle, an original-minded and eminently philanthropic Frenchman, of Leghorn, aware of the presence of boracic acid in the jets of steam which are emitted from the surface of the broken soil in the ravines of Monte Cerboli, on the margin of the Maremma of the Volterra in Tuscany, hit upon the happy idea of utilising the natural heat in lieu of fuel to effect the process of evaporation. Extemporized tanks fed by rills of cold water were employed to intercept the jets of steam until the fluid got charged with boracic acid; while other jets of steam, tapped from the soil, were led off in pipes and distributed under the evaporating-pans. An unbounded supply of boracic acid was the result. As a consequence, the borax of Thibet fell in value from 37*l.* or 40*l.* a ton to nearly half that price, until at length borax was exported from England at the rate of 10*l.* per ton to displace the native article from the bazaars of India. In Thibet the mineral occurs in the form of biborate of soda, that alkali in many places abounding in the soil: while in Italy the base is yielded in the form of boracic acid. In both cases the appearance of the base was coincident with a region of hot springs, which occurred at great elevations in the Himalayahs, and for the best account of their connection with borax he could refer to Dr. Thomson's 'Travels in Thibet.'

Connected with the Himalayahs, there was also a physical and vital phenomenon of still greater importance. Henry Colebrook, the first who, along with Colonel Crawford, measured the heights of the Dwalagiri, procured from the plateau of Chanthan in the Himalayahs, at a height of 17,000 feet above the sea-level, fossil bones, which were brought down and exported as charms into India, to which the natives attributed a supernatural origin, and called them "lightning or thunder bones." At the present time, during eight months of the year, the climate differed in no important respect from that of the Arctic circle, and in the whole of the district there was not a single tree or shrub that grew larger than a little willow about nine inches high. The grasses which grew there were limited in number, and the fodder, in the shape of dicotyledonous plants, was equally scarce. Yet notwithstanding this scantiness of vegetation, large fossils were found, of the rhinoceros, the horse, the buffalo, the antelope, and of several carnivorous animals; the group of fossil fauna as a whole involving the condition that, at no very remote period of time, a plateau in the Himalayan Mountains, now at an elevation exceeding three miles above the level of the sea, where we got the climate of the Arctic regions, had then such a climate as enabled the rhinoceros and several subtropical forms to exist. It would occupy too much time to explain the details of this complex phenomenon. He would briefly state that the only rational

solution which science could suggest was that, within a comparatively modern period, a period closely trenching upon the time when man made his appearance upon the face of the earth, the Himalayahs had been thrown up by an increment closely approaching 8000 or 10,000 feet.

The PRESIDENT said he was sure that every person present had been delighted with the philosophical observations which had fallen from Dr. Falconer; and it would be very gratifying to him if so great a traveller and so eminent a naturalist would become a Fellow of the Royal Geographical Society.

Mr. GODWIN-AUSTEN, having been called upon by the Chairman, said, since the Paper was written, his son had visited other districts. The survey was now being carried on from the Kara-Korum Pass into Thibet, and the work of last year had been carried round the Pangong lake. The district was the most remarkable of any that he had yet seen in the great Himalayan range. It was out of the British dominions; and the survey was being carried out by the Government of India solely in the interests of geographical science. This particular work was undertaken in consequence of the reports of travellers that there were to be found in this district some of the largest glaciers in the world. In the Report to the Indian Government* it was stated that the survey was undertaken simply to verify that point, and it had turned out to be the case. He did not know whether all persons present had any conception of the enormous dimensions of this Himalayan glacier system. It would enable them to form some idea of the magnitude of these glaciers if he stated that, assuming Hampstead and Highgate to be high mountains, the glaciers would extend as far south as Tunbridge in one direction, and two-thirds of the way to Cambridge in the other. Or, if they were to start from Neufchâtel, they might cross the Oberland and Monte Rosa, down to Ivrea, and even then they would be within the limits of this glacier system of the Himalayahs.

The meeting was then adjourned to 25th January.

Fifth Meeting, January 25, 1864.

SIR RODERICK I. MURCHISON, K.C.B., PRESIDENT, in the Chair.

PRESENTATIONS.—*Lieut. A. G. Clark (late I. N.); Hugh Thurburn; and John Conder, Esqs.*

ELECTIONS.—*Lord Richard Cavendish; F. A. Eaton; George Green; John Kempster; Simon Keir; Edward Mackeson; Rev. J. W. Tottenham; Hugh Thurburn.*

ACCESSIONS TO LIBRARY.—'Explorations in the Interior of the Labrador Peninsula,' by Professor H. Y. Hind, F.R.G.S. Continuation of Transactions (various), &c.

ACCESSIONS TO THE MAP-ROOM since 23rd December, 1863.—Philip's Atlas, Part 18—the Consulting Index. Railway Map of London, by E. Stanford. Two Geological Maps of Grossherzogthum Hessen-Darmstadt. Continuation of the Admiralty Charts and Ordnance Maps.

---

* By Major-General Sir A. S. Waugh, at that time (1860) the Surveyor-General of India.